GREEN ECONOMY GOVERNANCE AND REGULATION: GREEN INDUSTRY AND CLEAN TECHNOLOGY FOR SUSTAINABLE DEVELOPMENT

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Abstract

The green economy promotes economic growth while enhancing environmental and social well-being through the adoption of sustainable technologies, crucial for fostering development in line with environmental sustainability principles (Söderholm, 2020). This study aims to explore the integration of green industries and clean technologies into Thailand's economic framework, a critical step for advancing sustainable development and enhancing the green economy. Employing qualitative methodologies, the research involved in-depth interviews with a diverse group of eight stakeholders, including industry leaders, policymakers, and sustainability experts, to gather detailed insights into the implementation challenges and success factors. Content analysis was used to interpret the data collected. The findings underscore the importance of addressing significant challenges such as financial constraints, technological limitations, and regulatory inconsistencies. A strategic approach, incorporating government incentives, public-private partnerships, and international cooperation, is advocated to ensure alignment with environmental sustainability goals. Continuous monitoring and adaptive management are highlighted as essential for maintaining the relevance and effectiveness of these strategies. Ultimately, this strategic framework may serve as a model for global best practices in green economic development, marking a potential transformative advancement in sustainability.

Keywords: Green Economy, Green Industry, Green Technology, Sustainable Development

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1. INTRODUCTION

As global environmental challenges become increasingly severe, the need for sustainable development strategies has never been more urgent. The concept of a green economy has emerged as a transformative approach to align economic growth with environmental sustainability. This economic paradigm emphasizes the development of green industries and the adoption of clean technologies, aiming to reduce environmental risks and ecological scarcities while promoting human well-being and social equity (Georgeson et al., 2017; Nyangchak, 2022; Ullah et al., 2023). The green economy advocates for

a shift from the traditional growth model, which extensively relies on the exploitation of natural resources, to a more sustainable approach that includes efficient resource use, low-carbon strategies, and the preservation of ecological systems. This model not only focuses on minimizing environmental impacts but also emphasizes the enhancement of energy efficiency and the prevention of waste across all sectors of the economy (Organization for Economic Co-operation and Development [OECD], 2012; Prokopowicz, 2020). Within the green economy, green industries play a pivotal role. These industries adopt sustainable practices that minimize environmental footprints while maintaining profitability. Green industries encompass a range of sectors from manufacturing to energy production, each integrating innovative technologies and processes that support sustainability. The development of green industries is crucial for reducing pollution, conserving resources, and achieving economic resilience against environmental risks (Dura & Suharsono, 2022; Mehmood et al., 2024). Clean technology, or cleantech, refers to any process, product, or service that reduces negative environmental impacts through significant energy efficiency improvements, the sustainable use of resources, or environmental protection activities. This includes renewable energy technologies (such as solar and wind power), water purification systems, and advanced recycling technologies among others. Cleantech is essential for driving forward the green economy by providing the tools and innovations necessary for sustainable growth (Hou et al., 2023; Islam, 2023; Nehra et al., 2023). Ultimately, the integration of green industry and clean technology is fundamental to achieving sustainable development. This concept strives to meet the needs of the present without compromising the ability of future generations to meet their own needs, integrating three core elements: economic growth, environmental stewardship, and social inclusion (Lorek & Spangenberg, 2014; Jabeen & Khan, 2022).

According to Meksathit and Laohavichien (2023), Thailand's current economic growth heavily relies on its limited natural resources, some of which are non-renewable or take a long time to regenerate, such as petroleum, coal, and various minerals. This dependence causes the prices of these natural resources to increase in the global market, leading to higher production costs for industries. The use of energy from these resources contributes to global climate change, exacerbating environmental issues and the scarcity of natural resources. This has resulted in global problems such as severe flooding, earthquakes, unpredictable weather patterns, storms, and wildfires, which are becoming more frequent and severe than in the past. These issues have led to the concept of a green economy, which has gained international importance through the United Nations Environment Programme (UNEP). The green economy is defined as an economic system that improves human well-being and social equity while significantly reducing environmental risks and ecological scarcities. In its role as a pathway to sustainable development, the green economy is also a platform for balancing industrial production responsibilities towards the environment. This approach has evolved alongside the industry and business sectors' shift towards low-carbon production processes and efficient energy use, aiming to increase the share of clean energy with the long-term goal of reducing carbon emissions, a major cause of global warming and greenhouse gasses, thus creating an environmentally-friendly economic system (Aroonsrimorakot & Vajaradul, 2016; Merino-Saum et al., 2020). Thailand, as a newly industrialized country, is transitioning from an agricultural to a more industrially-oriented economy, with competitive industries such as coke production and petroleum refining ranking globally. The country's primary energy system still relies on fossil fuels, such as coal, petroleum, or uranium, which are not only finite but also major contributors to carbon dioxide emissions, leading to climate change and environmental issues. Thus, clean energy becomes a crucial alternative, characterized by resources other than fossil fuels, which are inexhaustible and non-polluting, offering a solution to the problems arising from fossil fuel use (Meksathit & Laohavichien, 2023).

Given its significance, studying green economy, green industry, and clean technology is not only timely but essential for ensuring sustainable development. These areas are vital for reducing environmental impacts, conserving natural resources, and promoting economic growth that benefits current and future generations. The transition to a green economy involves innovative approaches to energy production, waste management, and industrial processes, and studying these changes can provide valuable insights into effective strategies and the challenges that need to be overcome. While there is considerable research on the development of clean technologies, less is known about the rates of adoption across different industries and the barriers specific to various sectors or geographic regions. Understanding these barriers can help in designing more effective policies and support mechanisms. This study aims to explore and understand the implementation challenges and success factors of green industries and clean technologies within the context of sustainable development in Thailand. Through in-depth interviews, the research gathers qualitative insights from industry leaders, policymakers, and sustainability experts to develop a nuanced understanding of how green industries and clean technologies can be effectively integrated into the broader economic system to promote sustainable development.

The paper is divided into six major sections. Section 2 conducts a thorough literature review. Section 3 describes the research methodology, and Section 4 presents the study's findings. Section 5 discusses the findings, while the final Section 6 includes the conclusions, limitations, and recommendations.

2. LITERATURE REVIEW

The exploration of the green economy within the context of sustainable development represents a crucial area of scholarly interest, recognized for its significant contribution to societal growth and advancement across multiple dimensions. The green economy serves as a dynamic exemplar of sustainable development, particularly in the economic realm, impacting various facets of life. Emerging in recent years, this concept has become pivotal in mitigating poverty and enhancing living standards, thereby promoting the welfare of the population. Central to the activation of sustainable development, the implementation of green economy strategies necessitates the creation of a healthy environment.

This involves substituting traditional, environmentally harmful economic practices with sustainable alternatives, such as generating thermal energy from renewable sources rather than fossil fuels, which are known for their detrimental effects on the environment and all life forms. Moreover, sustainable development is defined by the efficient and ethical utilization and enhancement of both material and human resources. It aims to secure equitable rights and resource access for both present and future generations, ensuring that natural resources are utilized judiciously without depletion, and wealth is distributed fairly across communities (Ali et al., 2021; Al-Taai, 2021; D'amato & Korhonen, 2021; Zhang et al., 2022).

The green economy presents a viable pathway for achieving sustainable development, aligning economic growth with environmental stewardship and social equity. This paradigm addresses pressing environmental challenges such as resource depletion and climate change by promoting green industries and advancing clean technologies. Green industries incorporate environmental responsibility across all stages of their processes, from resource extraction to final consumption. This includes the adoption of practices like renewable energy utilization, and resource efficiency through the principles of reduce, reuse, recycle, and significant pollution mitigation efforts. Representative examples encompass solar energy production, sustainable manufacturing processes, and organic agriculture. Conversely, clean technologies specifically target the reduction of environmental impacts through enhanced resource efficiency and decreased pollution levels. The shift towards a green economy is crucial for mitigating environmental degradation, conserving resources, fostering economic opportunities through "green jobs", and enhancing public health. Achieving these outcomes requires a synergistic effort among governments, businesses, and individuals. Governments are pivotal in creating incentives for green investments and innovation via effective policymaking. Businesses are encouraged to implement sustainable practices and to further the development of clean technologies, while individuals can contribute by supporting environmentally conscious businesses and minimizing their own ecological footprints. Collaborative action is essential for cultivating a sustainable future (Bina, 2013; Marcon et al., 2017; Grillitsch & Hansen, 2019; Guo et al., 2020; Söderholm, 2020; Veleva, 2021; Adamowicz, 2022; Cheng et al., 2023; Srisathan et al., 2023).

Thailand is advancing towards developing a bio-circular-green (BCG) economy as a strategic response to mitigate CO^2 emissions. Edyvean et al. (2023) analyze the strategic actions necessary for Thailand to transition towards a sustainable bio-circular economy and compare these efforts with those of other nations. The move towards a circular economy is crucial for sustainable development, focusing on waste elimination and the use of renewable resources to support future consumption and enhance public well-being. Thailand's BCG economy action plan exemplifies efforts to spur innovation and adapt the economy for a "new normal" future environment. Effective implementation of this plan requires well-defined projects, adequate initial funding, and motivating incentives for industries. Moreover, timely and effective actions are essential for fostering a sustainable future. These actions should include the sharing of best practices, enhancing international cooperation, and improving coordination to benefit citizens, communities, and both the public and private sectors. Additionally, research and development (R&D) projects should aim to achieve regional, national, and global sustainability goals. While Thailand and other countries have adopted policies to develop a BCG economy, differences in approach and application underscore the need for better international coordination and understanding.

The implementation of the green industry strategy is increasingly recognized as essential for achieving sustainable production in industrial sectors. Green industry certification, a voluntary scheme, has been widely adopted to encourage Thai industrial entrepreneurs to embrace environmentally friendly practices. Noranarttakun and Pharino (2021a) assessed the progress and extracted lessons from existing green industry schemes, focusing specifically on small and medium-sized enterprises (SMEs) within the electronic products and electrical equipment manufacturing sectors. Their findings indicate that common practices such as waste segregation, minimization, and energy saving are prevalent among SMEs, aligning well with green industry criteria and compliance with environmental laws. However, the adoption of other environmental practices like greenhouse gas accounting, green labeling, and green supply chain management remains limited. The study also reveals that both green industry-certified and non-certified SMEs perceive financial, legal, social, personnel, technological, and policy factors as barriers to adopting green industry practices, with economic factors being significantly more challenging. Conversely, incentives, expertise, and technology were seen as facilitators for embracing the green industry, though financial support was considered less influential. The research suggests that incentive-based measures, including subsidies and voluntary schemes for green product certification, could effectively promote green industry adoption among SMEs in Thailand.

The global shift toward a greener economy, particularly in the industrial sector, has seen various initiatives to promote green industry policies. Among these, the green industry certification scheme, a popular voluntary measure, has been successfully implemented in large conglomerates and firms with international ties. However, its uptake among Thai SMEs has been minimal, with only 1.03% of registered manufacturing sector SMEs adopting it as of 2016. Noranarttakun and Pharino (2021a) explored strategic approaches to boost green industry adoption in Thai SMEs by conducting a strengths, weaknesses, opportunities, and threats (SWOT) analysis, supplemented with extensive reviews, in-depth interviews, and surveys. Findings indicate that while Thai SMEs are generally positive about green industry practices and show a willingness to adopt them, they are hindered by significant challenges such as limited internal resources, particularly in budget and green technology knowledge, and a lack of appropriate regulatory incentives. The study suggests leveraging global Sustainable Development Goals (SDGs) and Thailand's 20-year national strategy focused on sustainable development to encourage the adoption of economic-based incentives like sustainable procurement and voluntary green product certification, along with pragmatic regulatory mechanisms such

as green product laws and product taxes to facilitate sustainable growth among SMEs.

Meksathit and Laohavichien (2023) explored the influence of the green economy on the sustainable development of clean energy, differentiating between private enterprises and government power agencies in their study. Their research demonstrated a significant positive impact of the green economy on the advancement of clean energy. Notably, the study found that the utilization of resources, a critical dimension of the green economy, did not affect the accessibility of clean energy services, a vital element of its sustainable development. Furthermore, the analysis indicated that public organizations are more engaged in fostering sustainable clean energy development compared to private entities. This variation is primarily attributed to the hesitance of private organizations, which often stems from the substantial initial investments required for clean energy initiatives. Nevertheless, both public and private sectors in Thailand acknowledge the significance of promoting both green economic practices and the sustainable development of clean energy, aligning with the United Nations' SDGs.

Kamkankaew et al. (2023) conducted a review on the state of strategic green business process management (BPM), particularly noting its increasing prominence in academic discussions. Green BPM, which takes into account environmental and sustainability aspects of business processes, aims to optimize resource utilization and enhance process architecture to better align with ecological, economic, and social goals. This approach not only improves operational efficiency but also caters to individual needs through the strategic deployment of cloud resources, process audits, and business analysis. The study highlights that Green BPM involves integrating environmental considerations into various facets of business operations including eco-friendly logistics, production, and the development of products, services, and processes. Technical innovations and human resource management are also scrutinized for their ecological impacts. Additionally, outsourcing is identified as a potential strategy to bolster internal infrastructure with less environmental burden. The effectiveness of Green BPM in reducing costs, improving quality and adaptability, and minimizing environmental impacts is underscored. This approach necessitates collaboration among process designers, systems architects, and business engineers who employ tools like graphic analysis, visualization, information technology (IT) solutions, metrics monitoring, and defect identification to achieve these outcomes. Furthermore, the review reflects on a trial study conducted within Thai companies, which are noted for their environmental consciousness. This study focused on optimizing data consolidation energy use and demonstrated how strategic changes in resource allocation, procurement, eco-friendly marketing, and leveraging technological breakthroughs can significantly reduce the environmental footprint of businesses.

3. RESEARCH METHODOLOGY

The qualitative research method aims to investigate the contexts in which individuals or groups make decisions and exhibit specific behaviors, while also seeking to explain the underlying phenomena. This approach is typically organized into four key stages: 1) research design, 2) data collection, 3) data analysis, and 4) report writing (Phuangsuwan et al., 2024). This study utilized a qualitative research methodology to delve into the intricacies of decision-making processes and behaviors within individual and group dynamics. The core of qualitative research, as highlighted by its capacity to provide detailed explanations for observed phenomena, hinges on the utilization of open-ended dialogue during interviews. Employing semi-structured interviews facilitated a meticulous and purpose-driven data collection, tailored to align with the stated research objectives. This interview format is particularly beneficial for addressing essential research questions while providing the flexibility to thoroughly explore specific topics. It allows the researcher to steer conversations, ensuring focus on relevant themes, thus maintaining the dialogue's relevance to the research goals for both interviewers and interviewees. Such flexibility is deemed vital for capturing a comprehensive view of the investigated subject matter (Tümen Akyıldız & Ahmed, 2021; Islam & Aldaihani, 2022).

The interview protocol was carefully developed to elicit detailed perceptions from individuals actively involved in green economy sectors, particularly green industry and green technology, with a focus on promoting sustainability. Conducted in English, the interviews employed open-ended questions, which are presented in the Appendix, designed to stimulate comprehensive and nuanced responses. These interviews were carried out either in person or remotely via ZOOM, with audio recordings used to facilitate thorough analysis. In addition, the study employed a documentary method, analyzing secondary data to derive key insights. This rigorous methodological approach was intended to enhance the understanding of the challenges and success factors associated with implementing green industries and clean technologies in Thailand. It also aimed to explore how these sectors could be integrated into the broader economic system to support sustainable development.

Purposive sampling was utilized as a strategic participant selection method in this qualitative study. This approach is characterized by the selective recruitment of individuals based on the informed judgment of the researchers, specifically tailored to meet the unique requirements of the investigation. Purposive sampling is designed to deepen understanding of a particular group or phenomenon, focusing on individuals who can provide substantial insights due to their direct experiences and expertise (Etikan et al., 2016). For this study, the inclusion criteria targeted individuals aged 18 years old and older who were key stakeholders — such as industry leaders, policymakers, and sustainability experts. These participants were selected for their rich knowledge and active involvement in sectors related to the green economy, green industry, green technology, and sustainability. This targeted recruitment strategy aimed to gather contextually rich and relevant data, thereby enhancing the depth and integrity of the study's findings. A total of eight participants were recruited (see Table 1), and the data collection via interviews was conducted in April 2024, providing a contemporary snapshot of the issues and dynamics at play.

Table 1. Demographic information on the respondents and interview dates and times

No.	*Gender*	*Age*	*Stakeholder category*	*Date and time of interview*
1	Male	51 years old	Industry leader	April 22, 2024, at 09:00 a.m.
2	Male	49 years old	Policymaker	April 22, 2024, at 10:00 a.m.
3	Female	45 years old	Sustainability expert	April 24, 2024, at 09:00 a.m.
4	Male	42 years old	Policymaker	April 24, 2024, at 10:00 a.m.
5	Male	49 years old	Sustainability expert	April 25, 2024, at 10:00 a.m.
6	Female	47 years old	Industry leader	April 25, 2024, at 11:00 a.m.
7	Male	44 years old	Industry leader	April 26, 2024, at 01:00 p.m.
8	Female	50 years old	Policymaker	April 26, 2024, at 11:00 a.m.

Source: Authors' elaboration.

Table 1 presents a detailed overview of the eight participants involved in the study, comprising five males and three females, with ages ranging from 42 years old to 51 years old. The sample encompasses a balanced mix of stakeholder categories, including three industry leaders, three policymakers, and two sustainability experts, which ensures a diverse range of perspectives on the green economy and sustainable development. The interviews were conducted over a five-day period from April 22 to April 26, 2024, reflecting a methodical approach to data collection that allowed for consistent timing and minimized external variables. The even distribution across stakeholder categories underscores a deliberate effort to gather balanced insights from various sectors engaged in green economy initiatives. Moreover, the participants' age range suggests that they are experienced professionals, providing valuable context for understanding the perspectives and expertise represented in the study's findings.

To ensure the validity and credibility of the qualitative data collected, the researchers employed a member-checking process. As mentioned by McKim (2023), this technique involves presenting each respondent with their interview transcript and the researchers' interpretations for verification. By confirming the accuracy of both the raw data and its interpretation, this process strengthens the trustworthiness of the findings. Member checking allows participants to correct any misrepresentations, clarify their responses, and provide additional context if necessary. This approach enhances the study's validity by ensuring that the researchers' understanding aligns closely with the participants' intended meanings.

Content analysis served as the principal method for data analysis in this study, enabling a thorough and impartial examination of textual, visual, and verbal content. According to Krippendorff (2018), Limna et al. (2024) and Thetlek et al. (2024), this qualitative technique is pivotal in discerning significant patterns, themes, or categories within the data, which facilitates the drawing of insightful conclusions and interpretations. The analysis process entailed a systematic categorization of the data, which is crucial in ensuring the validity of the inferences made. This is achieved through inductive reasoning, allowing for the emergence of themes from the data itself rather than imposing preconceived categories, thereby enhancing the rigor and credibility of the analytical outcomes.

4. RESEARCH RESULTS

The study utilized in-depth interviews to gather detailed insights into the implementation challenges and success factors associated with green industries and clean technologies in Thailand, with the objective of understanding how these can be integrated into the broader economic system to enhance sustainable development. Participants included a diverse group of stakeholders — industry leaders, policymakers, and sustainability experts — who provided rich qualitative data. The interviews revealed several key implementation challenges. Table 2 shows the classification for finding items.

Table 2. Classification of findings items

Category	*Items*
Implementation challenges	• Financial constraints • Technological barriers • Regulatory inconsistencies • Market readiness issues • Skill gaps
Success factors	• Government incentives • Public-private partnerships • Community engagement • Sustainable business models • International cooperation • Increased awareness
Strategic approaches	• Holistic policy framework • Scaling successful projects • Enhancing R&D capabilities • Building green supply chain • Adapting to local contexts
Future challenges	• Aligning all sectors • Long-term policy support • Economic barriers • Educational and cultural shifts

Source: Authors' elaboration.

Table 2 presents a comprehensive classification of findings related to the implementation of green economy initiatives, derived from the study's qualitative interviews. The table is structured into four main categories: implementation challenges, success factors, strategic approaches, and future challenges. Each category contains specific items that emerged from the research's findings. The implementation challenges section highlights the primary obstacles faced, including financial constraints and technological barriers. Success factors enumerate elements contributing to effective implementation, such as government incentives and public-private partnerships. The strategic approaches category outlines key strategies for advancing green economy initiatives, including developing holistic policy frameworks and enhancing R&D capabilities. Lastly, future challenges anticipate upcoming hurdles, such as the need for long-term policy support and addressing educational and cultural shifts.

According to the interviews, it is crucial to address several implementation challenges and leverage key success factors to effectively integrate green industries and clean technologies into Thailand's broader economic system and promote sustainable development. Financial constraints, technological barriers, inconsistent regulatory frameworks, inadequate infrastructure, market readiness, and skill gaps pose significant hurdles. Conversely, success can be fostered through

government incentives, public-private partnerships, community engagement, sustainable business models, international cooperation, and increased awareness and education. A strategic approach should include developing holistic policy frameworks, scaling up successful pilot projects, enhancing R&D capabilities, building a green supply chain, and adapting initiatives to local contexts. Together, these elements can help ensure the successful adoption of green technologies in Thailand, aligning economic growth with environmental sustainability.

Furthermore, financial constraints were frequently cited, with many industry leaders discussing the high initial costs associated with adopting green technologies. Regulatory challenges also emerged as a significant barrier, including complex compliance requirements and a lack of supportive legal frameworks that could facilitate easier adoption of sustainable practices. Conversely, the research identified several critical success factors that facilitate the integration of green technologies and practices. Government incentives such as tax breaks, subsidies, and grants were noted as pivotal in encouraging industries to adopt green technologies. Technological advancements also played a crucial role, with many experts highlighting how innovations in clean technology have become more cost-effective and efficient over time, thereby increasing their attractiveness to businesses. Leadership commitment to sustainability goals within organizations was another vital success factor. Leaders who prioritized environmental issues were often able to drive change within their organizations by embedding sustainability into their corporate culture and business strategies. Moreover, the interviews underscored the importance of stakeholder engagement and public awareness in overcoming barriers. Participants suggested that increasing educational efforts to raise awareness about the benefits of sustainable practices could lead to greater public and corporate buy-in, which is essential for the broader adoption of green technologies.

"*One of the primary challenges is financial constraints. Many green technologies require substantial upfront investments which can be prohibitive. Technological barriers also play a significant role, as the availability of cutting-edge technologies is not always widespread. Additionally, Thailand deals with inconsistent regulatory frameworks which can complicate the deployment of these technologies*" (Respondent 1, personal communication, April 20, 2024).

"*Inadequate infrastructure, particularly in rural and underserved areas, limits the effective implementation of green technologies. For example, the lack of efficient transportation and energy grids can hinder the operations of green industries. This infrastructure gap must be addressed to enable a broader adoption of clean technologies*" (Respondent 2, personal communication, April 20, 2024).

"*Turning to market readiness and skill gaps is quite significant. Market readiness involves both consumer awareness and willingness to adopt new technologies, which is not always present. As for skill gaps, there is a clear need for more specialized training and education to equip the workforce with the necessary skills to support green industries. This gap can delay or even derail the deployment of innovative technologies*" (Respondent 3, personal communication, April 20, 2024).

"*Government incentives are crucial. They can take the form of subsidies, tax breaks, or funding for research and development. Public-private partnerships can also facilitate technology transfer and financial support. Moreover, community engagement is essential to ensure that the solutions are tailored to local needs, which increases the likelihood of success. These incentives create an environment where businesses and communities can more readily adopt and invest in green technologies*" (Respondent 4, personal communication, April 20, 2024).

"*Sustainable business models that emphasize long-term profitability and environmental sustainability are essential. They encourage businesses to adopt green technologies by demonstrating their economic viability. International cooperation, on the other hand, can provide access to advanced technologies and funding, while also facilitating knowledge exchange. This global collaboration is crucial for accelerating the adoption of green technologies and for adapting these solutions to local and international markets effectively*" (Respondent 5, personal communication, April 22, 2024).

"*A holistic policy framework is key. It should integrate all aspects of green technology adoption, from regulatory measures to incentives and from infrastructure development to education. Scaling up successful pilot projects to a national level can provide practical models that others can follow. Enhancing research and development capabilities will be vital for innovating and adapting technologies to fit local contexts*" (Respondent 6, personal communication, April 22, 2024).

"*It is vital to build a green supply chain and adapt initiatives to local contexts in ensuring the success of clean technologies. Building a green supply chain reduces environmental impact and can also be cost-effective in the long run. Adapting initiatives to local contexts ensures that the solutions are appropriate for the specific environmental, cultural, and economic conditions of an area, which greatly increases the likelihood of successful adoption and sustainability. This localized approach not only fosters community acceptance but also enhances the practicality and effectiveness of the technologies implemented*" (Respondent 7, personal communication, April 22, 2024).

"*As we look to the future, the biggest hurdles will be aligning all sectors of the economy with sustainability goals, ensuring long-term political and policy support, and overcoming economic barriers to investment in green technologies. Additionally, tackling the educational and cultural shifts needed to support these changes is a significant challenge that requires concerted effort across various sectors*" (Respondent 8, personal communication, April 22, 2024).

These findings illuminate the complex interplay of economic, regulatory, technological, and social factors that influence the successful implementation of green industries and clean technologies in Thailand. They provide a foundation for policymakers and business leaders to develop strategies that enhance the integration of sustainability into the economic development plans of the country.

5. DISCUSSIONS

The research highlights the need to address key implementation challenges to successfully integrate green industries and clean technologies into

Thailand's broader economic framework, promoting sustainable development and the growth of the green economy. Overcoming hurdles such as financial constraints, technological barriers, regulatory inconsistencies, inadequate infrastructure, market unreadiness, and skill gaps is crucial. These challenges demand targeted, innovative solutions tailored to Thailand's socio-economic landscape. At the same time, leveraging success factors — including government incentives, public-private partnerships, community engagement, sustainable business models, international cooperation, and increased awareness — will be instrumental in driving this integration. Government incentives, such as tax breaks and subsidies, can alleviate financial burdens and encourage investment in green technologies. Public-private partnerships can pool resources to drive innovation and implementation, while community engagement ensures that initiatives are well-received and integrated into local contexts, enhancing their impact and sustainability. Additional strategies include developing holistic policy frameworks, scaling up successful pilot projects, and strengthening R&D capabilities. Building a green supply chain adapted to local needs and fostering international cooperation for access to advanced technologies and best practices are also essential. Moreover, raising awareness and promoting education will help cultivate a culture that values sustainability. An alignment between the challenges and proposed solutions emerges: government incentives directly address financial constraints, while public-private partnerships and international cooperation tackle technological barriers and skill gaps. Similarly, holistic policy frameworks resolve regulatory inconsistencies, and community engagement combined with increased awareness addresses market readiness issues.

The study's findings align with those of Noranarttakun and Pharino (2021b), which indicate that a majority of SMEs in Thailand hold a positive perception of the green industry and express an intention to adopt its practices. However, the capabilities of SMEs, particularly in terms of internal resources such as budget and green technology knowledge, remain significant weaknesses, compounded by the absence of appropriate regulatory incentives. A key opportunity identified in the research is the global focus on SDGs and the 20-year national strategy that emphasizes green economy and sustainable development. For future strategic recommendations, the study advises policymakers to promote the implementation of economic-based incentives, such as sustainable procurement and voluntary green product certification schemes. Additionally, pragmatic regulatory mechanisms, including laws on green products and product taxes, are suggested to bridge the gap between current practices in green industry implementation and sustainable growth for SMEs. Moreover, Yi et al. (2022) presented findings that underscore the effectiveness of subsidy policies in incentivizing manufacturers to reduce pollution. The research indicates that when the marginal cost of investing in green technology is low, or the marginal damage cost of pollution is high, green subsidies are more beneficial than emission taxes in enhancing manufacturers' profits. Additionally, it was found that green subsidies yield higher profits for retailers compared to emissions taxes under conditions of lower marginal costs for green technology investment. Furthermore, the study demonstrates that manufacturers, and even entire supply chains, tend to be more profitable under environmental regulations than without them. This supports Porter's hypothesis, which posits that if the marginal cost of green technology is low or the marginal damage cost of pollution is high, governments aiming to maximize social welfare should opt for green subsidy policies over emission taxes. Conversely, if these conditions do not apply, the implementation of an emissions tax is recommended. Furthermore, Abulibdeh et al. (2024) assert that higher education institutions are pivotal in preparing future professionals with the necessary technological skills, necessitating updates to curricula and enhancements to infrastructure. Concurrently, the significance of education for sustainable development has been emphasized by global initiatives, including the SDGs. Education for sustainable development fosters a commitment to the economic, ecological, and equitable well-being of communities.

Furthermore, international cooperation offers a pathway to accessing advanced technologies and best practices from around the globe, which can accelerate the local adoption of effective solutions. Increased awareness and education among the public and within organizations are vital for creating a culture that values and prioritizes sustainability, influencing both consumer behavior and corporate strategies. By adopting a strategic approach that includes developing holistic policy frameworks, scaling up successful pilot projects, enhancing R&D capabilities, and building a green supply chain tailored to local needs, Thailand can ensure the successful adoption of green technologies. This strategic framework should not only address the immediate technical and financial aspects but also consider long-term sustainability and resilience against socio-economic shifts and environmental changes.

The study corroborates the findings of Sánchez-García et al. (2024), emphasizing the transformative impact of emerging technologies such as blockchain and artificial intelligence on the circular economy. It highlights the critical role these technologies play in community integration, ethical considerations, technological synergies, sustainable business models, and the expanding bioeconomy. The research concludes that new technologies offer the potential to significantly enhance resource efficiency, optimize supply chains, foster innovative business models, and improve product lifecycle management. These advancements promise substantial economic and environmental benefits, thereby promoting sustainable consumption and facilitating collaborative innovation. Alojail and Khan (2023) also highlight the importance of evaluating the efficiency of transformation processes and their long-term sustainability outcomes for organizations. Their research findings suggest that the integration of sustainability principles into digital transformation enhances the effectiveness of the transformation, as evidenced by improvements in environmental, social, and economic performance indicators. The distinctiveness of this study lies in its emphasis on embedding sustainability principles within the digital transformation process. The results demonstrate that organizations achieve better long-term sustainability outcomes when their digital transformation objectives are aligned with the SDGs. Furthermore, Vuola et al. (2020) argue that as national green economy policies evolve, it is

advisable to concentrate on the development of supportive legal, regulatory, and policy frameworks that facilitate the advancement of the green economy.

This holistic and concerted effort will align Thailand's economic growth with its environmental sustainability goals, setting a benchmark for other nations aiming to cultivate a resilient and sustainable green economy. The success of this endeavor will depend on the continuous evaluation and adaptation of strategies to ensure they remain relevant and effective in the face of evolving global and local challenges.

6. CONCLUSION

The effective integration of green industries and clean technologies into Thailand's economic framework is critical for advancing sustainable development and the green economy. Addressing substantial challenges such as financial constraints, technological limitations, inconsistent regulatory environments, inadequate infrastructure, market readiness, and workforce skill gaps is paramount. This requires comprehensive and context-specific strategies that leverage pivotal success factors including government incentives, public-private partnerships, community engagement, sustainable business models, international cooperation, and enhanced awareness and education. A strategic approach that encompasses developing robust policy frameworks, scaling up successful pilot projects, augmenting R&D capabilities, and constructing a resilient green supply chain tailored to local conditions is essential for fostering the adoption of green technologies. This strategy should focus on both the immediate facilitation of technology implementation and the building of long-term sustainability and adaptability within Thailand's socio-economic landscape. Through such integrated and forward-looking measures, Thailand can align its economic advancement with environmental sustainability objectives, setting a model for other nations pursuing similar transitions to a resilient and sustainable green economy. The success of these efforts will hinge on continuous monitoring, evaluation, and adaptive management to ensure that initiatives remain effective and responsive to new challenges and opportunities.

The integration of green industries and clean technologies within Thailand's economic framework presents both practical and academic implications, significantly contributing to the discourse on sustainable development and the green economy. From a practical standpoint, overcoming challenges such as financial constraints, technological limitations, and inconsistent regulatory environments requires tailored strategies that incorporate pivotal success factors like government incentives, public-private partnerships, and community engagement. These strategies are critical for the effective adoption of green technologies and the achievement of environmental sustainability. Academically, the study contributes to the body of knowledge by delineating a comprehensive framework that addresses both the immediate and long-term needs for sustainable development within an emerging economic context. It outlines the necessity of developing robust policy frameworks, scaling successful pilot projects, enhancing R&D capabilities, and constructing a green supply chain that is resilient and adapted to local conditions. This strategic approach not only underscores the importance of integrating sustainable practices into the core economic strategies but also highlights the role of education and international cooperation in fostering sustainable development. Furthermore, the study emphasizes the importance of continuous monitoring, evaluation, and adaptive management as vital components of sustainable policy implementation. This continuous cycle of assessment ensures that the initiatives remain effective and responsive to evolving economic, environmental, and social landscapes. By presenting these insights, the study offers a valuable model for other nations looking to navigate similar transitions towards a resilient and sustainable green economy, thereby enriching the global dialogue on sustainability practices.

While this study offers valuable insights into the integration of green industries and clean technologies within Thailand's economic framework, there are limitations that should be acknowledged. Firstly, the small sample size of eight stakeholders may constrain the generalizability of the findings. Additionally, the exclusive focus on Thailand's context limits the applicability of the results to other regions. Although the qualitative approach provides detailed insights, it may lack the statistical rigor associated with quantitative methods. Furthermore, potential biases in stakeholder perspectives could affect the interpretation of the data. The relatively short timeframe of the study may have also restricted the depth of the analysis. To address these limitations, future research could employ larger and more diverse samples, conduct comparative analyses across different regions, integrate mixed methods approaches, and undertake longitudinal studies. Additionally, involving a broader range of stakeholders could offer a more comprehensive understanding of green economic development. Further research should also explore the replicability of the identified factors in other developing countries and pursue empirical studies aimed at addressing the challenges of green economic integration.

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APPENDIX. INTERVIEW QUESTIONS

It is important to note that not all survey questions are asked of each participant. Certain inquiries are omitted selectively to ensure their relevance to specific respondents.

1.	What do you perceive as the main financial constraints in implementing green industries and clean technologies in Thailand?
2.	In your experience, what are the primary technological barriers hindering the adoption of sustainable practices in your sector?
3.	How would you describe the current regulatory framework for green industries? Are there any inconsistencies or challenges?
4.	What issues related to market readiness have you observed in the context of green technology adoption?
5.	Can you elaborate on any skill gaps you've noticed in the workforce that might impede the transition to green industries?
6.	What types of government incentives do you believe would be most effective in promoting the adoption of clean technologies?
7.	How do you see public-private partnerships contributing to the advancement of green industries in Thailand?
8.	What role does community engagement play in the successful implementation of sustainable practices?
9.	Can you provide examples of sustainable business models that you think are particularly promising for Thailand?
10.	How important is international cooperation in advancing green technologies, and what forms should this cooperation take?
11.	What strategies do you think would be most effective in increasing awareness about green technologies among the general public and businesses?
12.	In your opinion, what elements should be included in a holistic policy framework to support green industry development?
13.	What approaches do you recommend for scaling up successful pilot projects in sustainable technologies?
14.	How can Thailand enhance its R&D capabilities in the field of clean technologies?
15.	What challenges do you foresee in aligning all economic sectors with sustainability goals in the long term?